A Reconnaissance Gravity Survey of the Island of Molokai, Hawaii[1]

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During December, January, and February, 1962–1963, 72 gravity measurements were made with a La Coste and Romberg meter (G-8) on the island of Molokai. Stations were located and elevations determined on 1:24,000 scale modern topographic maps. A gravity station (No. 23) at the Molokai airport (Fig. 1), first established by R. R. MacDonald, was used as the primary base during the course of the survey. Because of limited time and the inaccessible nature of much of the island, especially the eastern part, the present survey is of a reconnaissance nature only. However, enough data are available to outline roughly the general gravity field of West Molokai Volcano and to permit speculation on that of East Molokai Volcano.

The help of the following residents of Molokai is gratefully acknowledged: Edward Burlem, Superintendent of Kalaupapa Settlement; James Linebaugh and Sakuichi Nakamura, Soil Conservation Engineers; and Henry Meyer, Operations Manager of Molokai Ranch.

GENERAL GEOLOGY

Molokai, situated southeast of Oahu, is the fifth largest of the Hawaiian Islands and consists of two shield volcanoes arranged along an east-trending line (Fig. 2). West Molokai Volcano is built mainly of thin basalt flows which dip gently from the high point of the volcano. It is flatter than most Hawaiian volcanoes and apparently the summit was never indented by a caldera (Stearns and Macdonald, 1947:15). K-Ar ages (McDougall, 1964) indicate that the last eruptions of West Molokai Volcano occurred about 1.8 million years ago.

Two rift zones marked by broad ridges radiate from the summit of the western volcano, one to the northwest and the other to the southwest. Numerous dikes have been mapped (Stearns and Macdonald, 1947) along the coast from 1 to 5 miles east of the northwest cape of the island along the trend of the northwest rift zone. No dikes have been mapped on the southwest rift, but a few dikes are exposed along the south coast and may define a possible southeast rift zone of the volcano.

On the northeast side of West Molokai Volcano are many faults which are downthrown chiefly toward the northeast (Fig. 2). They indicate collapse of the northeast slope and summit area of the volcano, apparently before East Molokai Volcano had attained its present size.

East Molokai Volcano is composed of two volcanic series, a lower unit of olivine basalts, and a relatively thin upper unit dominantly of mugearite and trachyte. The latest lavas are distinctly younger than those of West Molokai Volcano and overlap its east flank. K-Ar ages (McDougall, 1964) of the exposed rocks of East Molokai Volcano are 1.3–1.5 million years. These lavas were erupted from a central caldera complex, and from the west and east rift zones which intersect at the summit. These rift zones are marked by dikes and cinder cones (Stearns and Macdonald, 1947); Macdonald (1956:16) has suggested that another rift zone extends south from the summit.

On the north shore of East Molokai Volcano several faults dip south and are downthrown on their south side (Fig. 2). Especially thick lava flows are present here, where lava flowing north from the summit of the volcano ponded on the downthrown blocks.

The latest volcanic activity on the island of Molokai occurred north of the great sea cliff on the north side of East Molokai Volcano. A small vent 1 mile east of Kalaupapa extruded olivine basalt lava which built the low Kalaupapa peninsula nearly 3 miles north of the base of the sea cliff.

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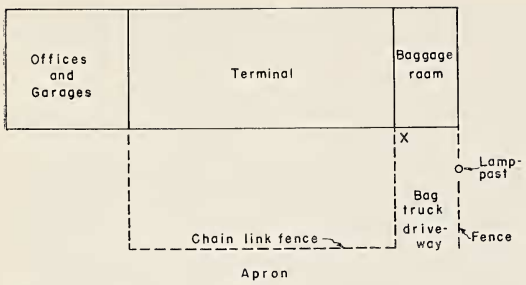

FIG. 1. Plan of Molokai airport. X, site of gravity station No. 23.

GRAVITY

A Bouguer gravity map (Fig. 3) was prepared for the island from gravity measurements from 72 stations. The table of principal facts is reported elsewhere (Hawaii Inst. Geoph., 1965, Table 3). As with gravity surveys of the island of Hawaii (Kinoshita et al., 1963), a density of 2.3 g/cc was used for the Bouguer corrections. No systematic tidal, drift, or terrain corrections have been made.

Like other Hawaiian volcanoes, West Molokai Volcano shows a well-marked gravity high near the center. This anomaly presumably represents the higher percentage of denser intrusive rocks and perhaps ponded lavas associated with the magma reservoir and central conduit of the volcano. This anomaly, however, lies considerably east of the high part of the volcano and, in fact, is largely within the area of extensive faulting on the northeast flank of the volcano. Much of this central positive gravity anomaly lies in the area covered by the younger lavas of East Molokai Volcano. The relationship of the fault system on the northeast flank of West Molokai Volcano to the gravity-defined volcanic center suggests that these faults, probably caused by gravity sliding to the north, encroached on the volcanic center in much the same way as the Hilina fault system is encroaching on the south flank of Kilauea Volcano (Moore and Krivoy, 1964:2043).

Gravity noses trending northwest and southwest from this central gravity high (Fig. 3) presumably define the major rift zones of West Molokai Volcano. A gravity nose extending to the east may represent an east rift zone of the west volcano, but in this region of overlap the possibility that this structure belongs to East Molokai Volcano cannot be eliminated. Control of gravity measurements on the south coast of West Molokai is insufficient to test the presence of a southeast rift zone.

The gravity measurements on East Molokai Volcano are few and are restricted chiefly to the south and east coastal region and to the Kalaupapa peninsula to the north. No gravity measurements were made near the mapped caldera complex and the character of the central gravity configuration is not known. Terrain corrections have been computed for four stations on East

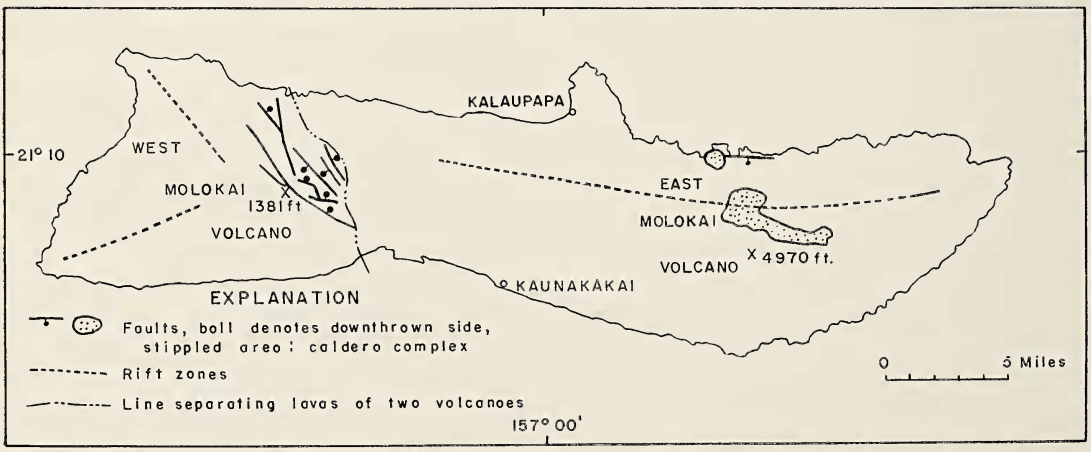

FIG. 2. Geologic sketch map of the island of Molokai. After Stearns and Macdonald (1947) and Stearns (1946).

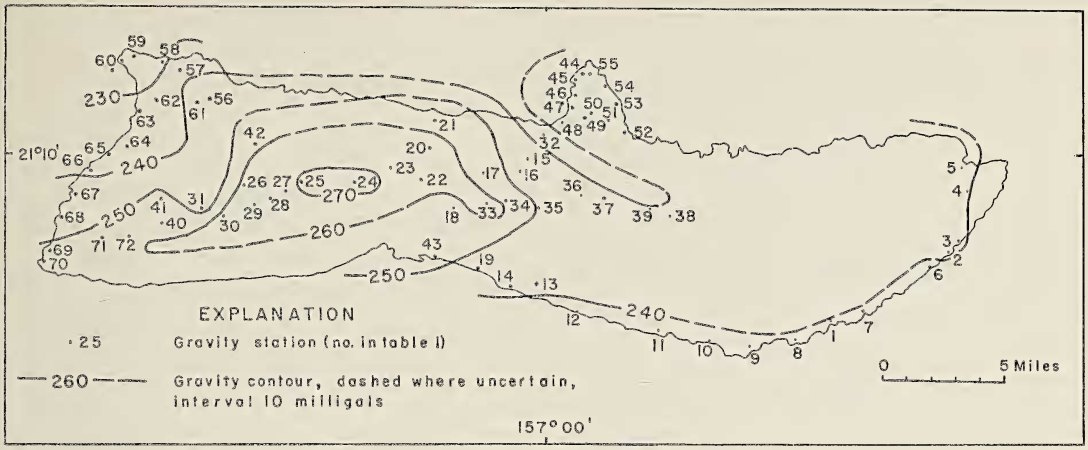

Fig. 3. Bouguer gravity anomaly map of the island of Molokai, Hawaii.

Molokai. These stations with terrain corrections in milligals are: No. 3, +1.6; No. 38, +16.5; No. 49, +4.6; and No. 55, +0.8. The terrain effects are particularly large in the central, rugged part of East Molokai, and here uncorrected values must be used with caution.

The gravity data on the south and east flanks of East Molokai Volcano are insufficient to define any rift zones. Although the coverage is incomplete, the data suggest that the rift zone on the west side of the volcanic center extends west-northwest from the summit of East Molokai Volcano through the Kalaupapa peninsula. The vent which extruded the lava flows that built the Kalaupapa peninsula was presumably fed by magma moving from the volcanic center through this rift zone.

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